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# <Notes>Vertical Zoning of Monsoon Asia by Agricultural Landuse : A Progress Report

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CITATION:

Takaya, Yoshikazu ...[et al]. <Notes>Vertical Zoning of Monsoon Asia by Agricultural Landuse : A Progress Report. 東南アジア研究 1976, 14(1): 99-122

ISSUE DATE:

1976-06

URL:

<http://hdl.handle.net/2433/55837>

RIGHT:

## **Vertical Zoning of Monsoon Asia by Agricultural Landuse: A Progress Report**

by

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### **Abstract**

Based on field work in India and Nepal, monsoon Asia is classified into five vertical zones in terms of agricultural landuse. The five zones are, from low to high altitude, 1) paddy dominant zone, 2) maize-millet and paddy zone with tropical plants, 3) maize-millet and paddy zone without tropical plants, 4) maize and wheat zone, and 5) potato and bitter buckwheat zone. This last has many animals. These zones correspond well to the topographic regions. The paddy dominant zone coincides with the Lowland and Highland regions. The maize zones, that is the zones 2) to 4) fall in the Hill region. The potato and bitter buckwheat zone corresponds to the Alpine region. Roughly speaking, the Lowland and Highland regions are the domain of rice, the Hill region of upland crops, and the Alpine region of animals. More detailed analysis reveals that the domain of rice is further divided into two areas, i.e. the photo-sensitive rice dominant area and the non photo-sensitive rice dominant area. The former is an area of poor drainage, while the latter is an area of good drainage. The domain of upland crops is also subdivided. There are a lower horizon of monsoon crops, a middle horizon of Mediterranean type crops and a higher horizon of Alpine crops. At the highest altitude, the landuse pattern becomes a nomadic one, heavily dependent on animal raising rather than soil cultivation.

## **I Geographic Setting**

### **I-1 Topography**

A N-S profile of the Himalayan region from Tibet to the Gangetic plain of India through Katmandu is illustrated in Fig. 1. The profile shows that this area can be divided into four regions based on altitude and the degree of brokenness of the ground surface. From north to south they are: 1) a very high altitude region with steep slopes, 2) a hilly to mountainous region of middle altitude, 3) a gently undulating low region, and 4) a very low-lying region.

Field observations show the following evidence for each topographic region.

- 1) The steep slopes of the very high altitude region are almost entirely composed of rocky surfaces. Only very limited portions are found to be level. These level areas are in most cases terminal moraines, where black Alpine soils with marsh and ponds

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are found.

- 2) The hilly to mountainous region of the middle altitude is a complex of hill slopes and valley bottoms. Hill slopes are normally covered by brown forest soils, whereas valley bottoms have either rocky gorges or tiny alluvial plains.
- 3) The gently undulating low region is composed of a complex of fans which developed at the edge of the hilly region. This region is still in the process of formation in the geological sense. Streams spread sandy loads on the ground surface and shift their course during flood seasons. The ground is very sandy, and as surface water percolates easily into sandy ground, this is a water deficit area.
- 4) The very low-lying region coincides with the Gangetic floodplain. Being the lowest-lying among the four regions, this area receives water, so it sometimes becomes a water excess region. Many parts are submerged deeply during the flood season. The soil is generally clayey and fertile.

The four topographical regions classified above will be called the Alpine, Hill, Highland and Lowland regions respectively in this report.

## **I-2 Climate**

All 4 regions have a monsoon climate. At Katmandu, which is located at the middle of the profile, the period from June through September is warm and pluvial. This is the season of the south-west monsoon, during which the prevailing wind is from the south-east in the Katmandu valley. From October through February it is dry and cool. Temperatures sometimes drop below freezing from December to February.

Katmandu is located at about 1350 m above sea level. When we go south, or to the lower altitudes of the Highland and Lowland regions, we encounter a more tropical type of monsoon climate, where the climate is characterized by hotter and more humid summers and drier winters. By contrast, when we go to higher elevations in the north, the monsoon cycle becomes less pronounced, at least in terms of relative humidity. Kawakita<sup>4)</sup> suggests constant high humidity throughout the year by pointing out the existence of mossy forests and epiphytic orchids above 1700 m. Thus, the region shows climatic zoning, starting from the tropical monsoon climate in the Lowland, through a temperate monsoon climate in the Hill regions to a cool climate in the Alpine region. Behind the crest of the Great Himalayas, the climate suddenly becomes very dry because the humid southeast monsoon is shut out by the mountain range.

In order to describe the climate of the Himalayan region in more detail, horizontal variations in the east-west direction must be mentioned. Discussion of this topic is, however, omitted from this paper.

## **I-3 Vegetation**

According to Kawakita<sup>4)</sup>, who has made a diagrammatic representation of the distribution

of major vegetation types of Nepal, the vegetation zone of Central Nepal can be described roughly as follows:

At altitudes lower than 1200 m, *Shorea* locally called *Sal* is the sole dominant of the original vegetation. Between 1200 m and 1900 m, the original vegetation is characterized by *Schima* and *Castanopsis*. The former is called *Chilauni* in Nepalese and its leaves are used as fodder when they are young. The nuts of the latter are occasionally collected and eaten by local people.

Lucidophyllous trees dominate from 1900 m to 2500 m. Various species of evergreen oak are found as co-dominants, among which *Quercus glauca* is characteristic. Very often pure stands of *Q. semicarpifolia* are seen at a level between 2500 m and 2900 m, although conifer trees such as *Tsuga* and *Picea* are also frequently found. *Q. semicarpifolia* which is called *Phesing* by the Sherpas is one of the most important fodder trees at this altitude. At elevations higher than 2900 m, *Abies* is dominant. But this may merge to *Betula* and *Rhododendron* in the more moist places.

*Abies* is the upper limit of the forest zone at about 3900 m, and above this level is the zone of vascular plants.

Roughly speaking, the *Shorea* zone coincides with the Highland region, the three evergreen tree zones, that is the *Schima-Castanopsis* zone, *Evergreen oak* zone and *Quercus semicarpifolia* zone, fall in the Hill region, and the *Abies* zone and the vascular plant zone correspond to the Alpine region.

#### **I-4 Cultural Landscape<sup>2)</sup>**

The four topographic regions seem to correspond to four different cultural regions.

The Alpine region may be considered as a southern extension of the Tibetan cultural complex. In the Alpine region people follow the Tibetan tradition in language and religion. In this harsh terrain with thin air and jagged topography, people rely on animals which live on the grasses and shrubs which grow on the rocky ground surface. Soil cultivation is very minor.

The other extreme, that is the lowland of the Gangetic floodplain, is the heart land of Indian culture. Caste-stratified society and the Hindu religion have flourished since ancient times. Economically, rice growing is essential. Rice is often grown in very deep water.

The Highland region is popularly called Terai. The prevalence of malaria has long hindered human activities in this subtropical region. It is only during this century that the region has been transformed into extensive paddy land after the eradication of malaria. Although this is rice land, the general features are very different from the Gangetic floodplain. Terai is primarily a dry and water-deficient area. Paddy cultivation has been and still is under constant threat of drought. This development has been carried out from the areas adjoining the Gangetic plain, by people who speak the Indo-Aryan Terai dialect. So this region is a kind of northern extension of the Indo-Aryan world.

The Hill region sandwiched between the Highland and Alpine regions is a complex of hill slopes and valley bottoms. The hill slopes are the domain of Mongoloid tribes who speak Tibet-Burmese dialects. They cultivate African millet and maize on sloping dry fields. The valley bottom, which are in many cases recently developed, are dominated by the Indo-Aryan people who brought the techniques of paddy cultivation from the south. They grow rice by irrigation. The picture of rocky crop fields with very poor crops, and over-grazed barren spots suggest that the hill slopes are already suffering over-population. The authors in 1975 encountered various groups of people who had just moved down from hill slopes to near-by valley bottoms. They did not meet people who had migrated from the hill slopes of the Hill region to the Terai, although this flow has been recorded on a larger scale by the census.

## II Field Observation

Descriptions of the landuse pattern of 19 sample sites are made below.

The location of the sample sites can be checked by the locality numbers on the profile shown in Fig. 1.

The cropping calendars in the case of Nepal are all recorded by special symbols which correspond to the months in the Nepalese calendar. They are as follows: I means the latter half of January and the first half of February which corresponds to *Magh* of the Nepalese calendar, II stands for *Phalgun*, III for *Tseit*, and so on, up to XII which represents the latter half of December and the first half of January, standing for the month of *Pus*.

### II-1 Gangetic Floodplain

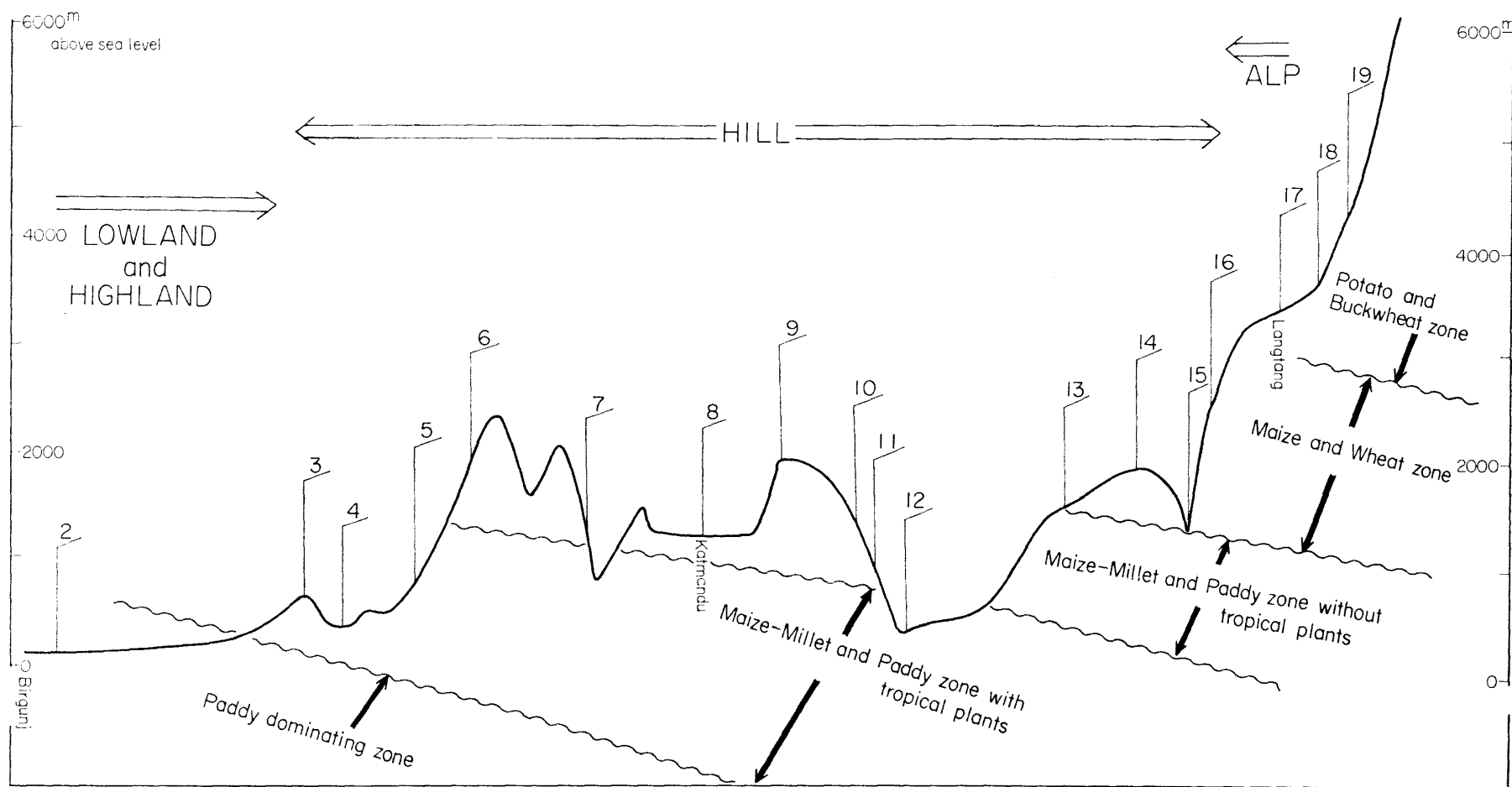
#### *West Bengal (Loc. 1)*

Although the Lowland region is very low-lying, it is by no means a flat land. The local relief is caused by the web of levees and backswamps and reaches two to five meters. Two to five meters do not appear great, but this is significant in the Lowland region where most of the parts are submerged under water during the rainy season. It is said<sup>1)</sup> that local people classifies their farm lands with regard to elevation into three categories, *jala* or the land below water level, *sunā* or the land above water level and *danga* or an elevated portion.

There are other lands called *bastu* and *unbastu* at higher levels, of which the former is the place for homestead and the latter the immediately around the homestead.

Typical cropping patterns seen in West Bengal is as follows:

	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
jala																
deep inund. jala																
sunā																



**Fig. 1** A N-W profile through Katmandu, with sampling sites and landuse zones

- 1) West Bengal, 2) Birgunj-Kalaiya, 3) Nayabasti, 4) Hetaura, 5) Kalitar, 6) Aghore, 7) Sopyang 8) Katmandu, 9) Kakani hill top, 10) 1550 m on north slope of Kakani, 11) 1000 m on north slope of Kakani 12) Valley bottom at Trisuli, 13) Ramche, 14) Bhargu, 15) Syabrubensi, 16) Syarpagaon, 17) Langtang, 18) Kyangjingompa, 19) Nubmathang

The cropping pattern is strongly controlled by the landform. At *jala* or the low level, what they called *Aman* rice is cultivated. The *Aman* rice is usually transplanted at the beginning of the rainy season and grow in inundated fields. But at some parts of the *jala* field, the flood comes very violently and the flood level rises very rapidly. In these places, broadcast must be carried out. In the case of the broadcast, seeds are sown on dry lands during the period from April to July and let them grow together with weeds. When the flood comes in September the weeds which have been vigorously growing by this time are all drowned and only the rice plants which are special varieties resistant to flood survive. A variety which can grow as tall as 3 meters or more to catch up the flood level is commonly called floating rice. This is a variety of broadcast *Aman* rice adopted to the deeply and rapidly flooded plots. *Aman* rice is in most cases harvested from the end of November through December. But some remain in the fields as late as February or even later when they are cultivated in poorly drained plots. *Aman* rice is occasionally followed by pulses. Some pulses are said to be broadcasted in *Aman* fields in October while the rice plants are still standing, and harvested during February and March.

The *Suna* or the middle level is in general, the land for *Aus* rice. The *Suna* is higher in elevation and coarser in soil texture than the *jala*, thus this is better drained than the *jala*. *Aus* rice is in most cases broadcasted on uninundated fields. The sowing is made in May and reaping is made in August or September. But when water is available for ploughing and harrowing, transplanting is made. After the harvest of *Aus* rice, the plots are planted to pulses in October or November and they are harvested in February or March. The pulses grown on *Aus* fields are supposed to be of better quality than those inter-cropped in *Aman* fields.

A part of the *suna* is planted to jute or sugar cane. Jute loves sandy to loamy soils of the *suna* and stays in the field from May to September. Sugar cane, on the other hand, likes clayey soils and takes a whole year to get matured. Sugar cane has been losing its popularity among farmers, because of the long maturity period.

There is another rice called *Boro* rice. This off-season rice is planted at such very low places as the edges of ponds and river banks in receding water. Ploughing is not done. Only weeding is done, and the rice plants are transplanted in January.

The *danga* is the place for vegetable growing. Among vegetables grow on *danga*, gourd, pumpkin, cucumber, chili, and radish are important for summer crop, and potato, cabbage, and cauliflower are popular as winter crops.

## II-2 Terai

### *Birgung-Kalaiya Area (Loc. 2)*

A bunch of untamed streams which flows down from the loose sandstone hill of the Churia range has been and is still forming a very well developed fan complex just south of the range. Because of sandy, or even gravelly parent materials, the fan is quite sandy and

porous, and the surface water sinks down quickly into the ground. The area appears to be water-deficient, though it may have fairly large amount of groundwater.

As is common in any other fan, this area shows mosaic of relative heights and relative swales. According to maps made before the Second World War, most of the relative heights were still covered by *Sal* forests and only the relative swales were cultivated. But now the area is seen as a very wide expanse of grain fields, leaving nearly no trees.

The agricultural land of the Birgung and Kalaiya divisions may be categorized into three groups, namely rain-fed paddy field, irrigated paddy field and upland field. Typical cropping patterns of each category are as follows:

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
rain-fed paddy																
irrigated paddy																
upland																

There are variations even within the rain-fed fields. In drier portions, broadcast method is commonly adopted, where what local people call *Saro dan* (literally means hardy rice) is broadcasted in V on dry fields and harvested in X. Because of the dry condition of the fields, weeds overwhelm the rice and weeding is an unavoidable job, particularly during early monsoon season. In poorly drained plots, on the other hand, tall varieties are planted in inundated fields. In some plots, wheat follows rice. Wheat has gained popularity very remarkably in the last 10 years or so, and this has resulted in the expansion of the rice-wheat double cropping. It must be noticed, however, that this wheat dissemination is a new phenomenon induced by the arrival of the so-called high yielding wheat. In this paper, this type of high yielding wheat is called new wheat in order to distinguish it from the traditional wheat. The traditional cropping pattern of the area is one rice crop a year.

Irrigation is done solely by deep well tubes at the present stage. Newly introduced high yielding varieties of rice such as IR and CH series of rice are well accepted as the pre-monsoon rice. There are pre-monsoon local varieties too, such as Sherpalithalis, Khasturi, Phusam and Paitalis. For the second rice, many traditional varieties are planted. In some fields, wheat follows the second rice as the third crop. Wheat is broadcasted on flat fields after ploughing by tractor. (See Kurita<sup>5)</sup> for the varieties of rice in Terai and Hill regions.)

Upland fields are mostly confined along the northern periphery of Terai but occasionally found in the south too. African millet (*Eleusine coracana*) and maize (IV to VIII) are the main crops. Upland rice is occasionally cultivated from IV to VIII and this is followed by



pulses. The acreage of upland fields is, however, very small.

## II-3 Churia Range and Inner Terai

*Nayabasti (Loc. 3)*

The Churia range is the first and the lowest hill we meet when we come into the Hill region from Terai. Many parts of this range is still covered by *Sal* forest, but the opening of the forest has been being made quite rapidly in the last ten years or so by the Tamang people who migrated here from the eastern part of the Hill region. A representative cropping pattern adopted at Nayabasti (which literally means “New village”, though this is actually one of the oldest villages in the area, opened as old as 30 years ago) located on the northern slope of the range, at about 600 m above sea level is as follows.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland					<p>Maize</p> <p>A. Millet</p> <p>Pulses</p>											

Being located on a low hill slope, the catchment area is so small and the place suffers from almost permanent water shortage. Paddy growing is absolutely impossible. The main crop is maize. This is followed by pulses. Sometimes African millet follows maize. In the latter case, millet is inter-planted between standing maize plants. Occasionally buckwheat is grown after maize during the period of VIII and XI. According to local people, wheat cannot be cultivated due to the moisture deficit in the soil. Less than ten percent of the cultivated land is planted to upland rice. This crop is sown in IV and harvested in VIII.

*Hetaura* (Loc. 4)

North of the Churia range and south of the Mahabarat range lies the so-called Inner Terai. This is an east-west oriented valley about 10 km wide formed by the Rapti river. Cropping pattern typically seen at Hetaura is as following.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
low portion						Rice						New Wheat				
elevated portion					Maize				Pulses		Mustard					

The floodplain of the Rapti river is uneven, having local relief of several meters. The lower portions are used as paddy fields, where the crop is monsoon rice which is planted in VI and harvested from the end of X through XI. Local variety called *Gola* is popular but recommended varieties are also planted. In those plots where water is available throughout

the year, pre-monsoon rice precedes the monsoon rice. An informant told the authors that *American* and *No. 40* were the varieties he grew as pre-monsoon rice. These are both new varieties. According to him, the monsoon rice gives better crop than the pre-monsoon rice though the former is more susceptible to pest. Wheat is commonly cultivated after monsoon rice. But this is again a new fashion as in the case of Terai. The combination of rice-rice-wheat a year exists, but it is very few.

At elevated plots, maize is the main crop and followed by pulses or African millet. It is also seen that maize is followed by mustard after an idle period of about three months.

#### II-4 Southern Face of the Mahabarat Range

The Mahabarat range is composed of schist and gneiss with subordinate granite bodies and has a much greater height than the Churia range. Along a highway which links Katmandu and India across this range via Simbheingang pass, patches of cultivated land are found scattered on deeply forested slopes. The cropping patterns of two representative places are described to give a rough idea on the landuse on the southern face of the Mahabarat range.

##### *Kalitar (Loc. 5)*

Kalitar is a Tamang village opened about 70 years ago. The height of the sample site is about 900 m above sea level. This represents a lower portion of the Mahabarat range. Majority of the cultivated lands is upland. Small fractions which are confined in narrow valley bottoms are used as paddy field. Typical cropping patterns are as follows.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland				Maize				A. Millet								
paddy					Rice								New Wheat			

In upland fields, the absolutely important combination is maize-African millet. The sowing time of the maize may change in a range of three months. If rain comes early people prefer to sow it in II, but usually they have to delay the sowing until IV waiting the rain. New wheat may be grown after African millet. When the maize is not inter-planted with African millet, maize may be followed by one of such crops as mustard (IX-XII), buckwheat (early IX-late XI) and pulses (VIII-XI). Small amounts of upland rice are cultivated during IV to VIII.

In the paddy fields, monsoon rice-wheat combination is typical. When a perennial flow is available, people grow pre-monsoon rice besides the monsoon rice. In this case, they make nursery in I, transplant in early IV, harvest it in early VI, and then quickly plough for the main season rice.

# *Aghore (Loc. 6)*

This is again a Tamang village. The sampling site is located at 6817 ft above sea level (according to the one inch to a mile map) and represents the high level of the Mahabarat's south facing slope. Cropping pattern seen at this level is as following.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland																

Potato and radish are almost only crops grown here. The potato takes six months from II to VIII, and this is supposed to be the most superior potato in this region. With the same growth period, maize is cultivated in a small amount. But they never give good crop. According to local people, fog and Saringga (strong winds blowing in VI through VII) are very much harmful for this crop. After the potato is harvested, radish is grown extensively. Part of this is eaten green but the rest is kept after sun-drying. It is said that occasionally people tried to grow buckwheat and millet, but every time they got disappointed with miserable results. Wheat and mustard are completely lacking.

When we continue ascending from Aghore further, soon we find *Quercus semicarpifolia* standing mixed with *Rhododendron* and other ever green trees. Near the Simghingeang pass, the vegetation changes to a pure stand of *Q. semicarpifolia*.

## II-5 Northern Face of the Mahabarat Range

### *Sopyang (Loc. 7)*

A stretch from the Tsistungdeurli pass to Naubise on a valley bottom gives informations on the northern face of the Mahabarat range. The general landuse pattern of this face is similar to that of the southern face of the same range. The following is the cropping pattern commonly seen at the level of 1150 m. This elevation coincides with the upper limit of the sugar-cane cultivation.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland																
paddy																

In upland fields on the hill slope, maize-African millet is the core crop combination. About ten percent of the upland fields are cultivated to upland rice. When upland rice is grown, it is usually followed by one of such crops as new wheat (IX-II), buckwheat (VIII-end of XI), potato (IX-I) and mustard (X-I). In paddy fields, which share only very small



Vegetables grown during summer time are cucumber, okra, cucurbit, tomato, brinjal, chili, beans, cowpeas and cluster beans. Among winter crops are onion, garlic, turnip, cress, spinach, coriander, cauliflower, cabbage, beet, broadleaf mustard, potato, carrot, peas, methi lettuce, celery and asparagus.<sup>3)</sup>

One of the characteristic features of agriculture in the Katmandu valley is that the landuse is so intensive that there is not enough wasteland left to graze animals. The result is the shortage of green manure and compost. Traditional rice farming used to be heavily dependent on manure and *Kalimati* (black colored peaty soil dug from underground), but this has been being replaced by chemical fertilizer.

## II-7 North of the Kakani Pass

A descending along the Trisuli highway from the top of the Kakani hill (6778 ft according to a topographic map of one inch to a mile) to the valley bottom at the Trisuli-Tadi Khola confluence (about 1870 ft on the same map) shows a vertical landuse zone. Four representative cropping patterns are described below.

*Kakani hill top (Loc. 9)*

Tamang people living near the hill top adopt the following cropping patterns.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland			Maize							Radish						
			Potato						Potato							

People here have several varieties of maize. The most important one is a variety which is harvested during VIII and followed by radish. But other varieties are of late maturity and harvested during X. Maize sometimes suffers from frost damage during its youngest stage in II. Farmers said, "Occasionally we have very cold night in Phalgun (II). Warm temperature of the following morning is very dangerous. Maize dies almost immediately when the sun rises." Snow fall is seldom but frost occurs for three months from the middle of XI to the middle of II. Radish is usually sown after maize field is cleared, but sometimes it is sown between the standing plants. Radish can be harvested in XI, but it grows larger when it is kept in the field until I. The reason people like to pull the radish up in XI is that by doing so they can graze animals in the fields and let them drop dungs on the fields which are again to be planted to maize next spring. Bulk of the radish is sold green on the highway and the rest is sun-dried for preservation.

Another combination is potato-potato. The first potato is from II to VI. This is grown quite widely and is a cash crop. The second potato is for home consumption. Some of the first potato are followed by radish and occasionally by mustard. But the mustard usually does not grow well and is eaten as green by man and cattle.

In very limited places, rice is seen grown. A farmer explained that he was able to grow rice at this high place because he was smart enough to open his rice field in a window shadow place. The opening of the field was only two years ago, and his knowledge on rice was poor. He said that rice variety he was growing was *Pani Biu* (translated by our interpreter as water seed) and he also said it was a *Shiso gaiya* (high altitutde unpland rice). His statements confused the authors. At any rate his field was wet paddy field. He made his nursery in IV and transplanted in VI. He will harvest it in XI. He also said that *Rato Marsi* (red Marsi) was cultivated just below his field and *Seto Marsi* (white Marsi) was cultivated further down below.

*At the level of about 1550 m (Loc. 10)*

Upland fields are far more than paddy fields in acreage. Typical cropping patterns are as following.

	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V
upland			Maize				A. Millet									
paddy				Rice								Wheat				

In the upland fields, African millet is the most popular crop following maize. But buckwheat (VIII-XI), radish (VIII-I) and pctato (VIII-I) are also grown in stead of African millet. Wheat is never grown after maize, because this crop, when grown, occupies field until the end of IV which is already too late for maize to be sown.

In the paddy fields, *Nambura Marisi* and *Sokhaf Marsi* are two dominant varieties. These are sown in early V, transplanted in VI and harvested at the end of X. Many of the fields are then planted to wheat. Most of wheat grown today is the new wheat, though they had tradition of growing wheat even before the introduction of the new wheat.

*At the level of about 1000 m (Loc. 11)*

Pure stands of *Shorea* begin to appear at a level around 1200 m. Although the sample site is on a slope, terraced paddy fields occupy about half of the cultivated land. Some of the paddy fields are provided with irrigation sluices. Thus there are seen three land types; upland field, rain-fed paddy field and irrigated paddy field. The following is the cropping pattern commonly adopted by a Bahun farmer at this elevation.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
upland					Maize			A. Millet								
rain-fed paddy						Rice										
irrigated paddy		Rice						Rice								

All the upland fields are cultivated to maize during summer time, and nearly all of them are inter-planted by African millet when maize becomes the earing stage. People claimed that the climate there was too hot to grow buckwheat and soil was too moist to grow pulses.

In rain-fed paddy fields, *Phahito Marsi* is planted during the monsoon season. Most of the paddy fields are left idle until the next rice season after the harvest, but very small portion is followed by new wheat from early XII to IV.

In irrigated paddy fields, monsoon rice is, of course, the main crop. Varieties commonly grown are *Sherpanitalis*, *Khouchini*, *Thankhote Marsi* and *Thaijin*. One distinctive difference between the rain-fed fields and irrigated fields is that the latter often has the pre-monsoon rice. In the case of the pre-monsoon rice, the nursery is prepared as early as the end of I and the transplanting is made in early III. When the harvest is finished in the middle VI, the monsoon rice seedling which is ready by this time at another place is hurriedly transplanted. Popular varieties for pre-monsoon rice are *Sanudaraphini*, *Shededude*, *Khipua* and *Baglangue*.

One characteristic feature at this level is sugar cane fields. Sugar cane is cultivated in rotation with rice. People harvest only one crop and the ratoon is not exploited. They said that the first year was all right but from the second year the plots would become the nest of *Khumura Kira* (a kind of grub) which destroys all the sugar cane plants. Whenever they find the *Khumura Kira*, they convert the sugar cane fields into paddy fields to kill the animals by inundation.

#### *Valley bottom (Loc. 12)*

The valley bottom is a real tropical world. Mangoes are so many and papaya, banana and guava are also not rare. The valley bottom has two topographic units; floodplain and river terrace. The former is low-lying, very near to streams and in general well watered, while the latter is high from streams and has dry soils. The two have the following cropping patterns.





pass (Loc. 9) and Aghore in the Mahabarat range (Loc. 6) which have higher altitude than this Ramche village, the cropping patterns are not like this. In the south, maize is usually inter-planted by African millet, thus fields are practically planted to two crops a year. But in Ramche the fields are used for only one crop a year. Even more important fact is that this is a traditional wheat area. Wheat has been an important crop since ancient times. And barley is also indigenous here. Sometimes this rotation is broken by the planting of turnip, radish (both IX-III), potato (II-VII), buckwheat (VIII-XI), or upland rice (IV-IX). But these forms only a minor portion. Paddy is not seen due to too steep slopes.

*Bhargu (Loc. 14)*

The sampling site is about 1900 m. Evergreen oak forest including many of *Quercus incana* (?) is typically seen at this level. The black colored soil is seen more often than at Ramche. Tamang people adopt the following cropping patterns.

[illegible]

Maize, wheat and African millet are cultivated in rotation at this sampling site too, and this combination makes the core pattern of the area. But other crops are also not rare. There are potato (III-VII), buckwheat (VIII-X), radish (VIII-XI) and grain Amaranths (II-XI). Upland rice is also cultivated during IV and IX but this is in a small amount. Characteristic is the mixed cropping of grain Amaranths, soy beans (IV-VIII) and maize. In this case, maize is harvested first and then the other two are harvested two to three months later than the maize.

In 1973, paddy was introduced to this place for the first time, and since that time it has been cultivated successfully, though in a very limited plots. Variety grown in 1975 is a modern variety called Bikas (literally means development). This is sown in early VI in the nursery, transplanted in late VI and harvested in XI.

*Syabrubensi* (Loc. 15)

The village is located in the valley bottom at the confluence of the Trisuli Khola and the Langtang Khola. The altitutde is about 1400 m. On and near the valley bottom are found two types of landuse patterns as shown in the following.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	
on valley bottom						Rice							Potato				
near valley bottom					Maize					Buckwheat							

The paddy cultivation started 13 years ago. When the author asked the name of the

variety grown there, informants answered *Bre*, which merely means rice in his Tamang language. The rice-potato combination is found on irrigated plots. Maize-buckwheat combination, on the other hand, is found on the non-irrigated plots near the valley bottom. In some plots, the combination of maize and inter-planted African millet is also seen.

Noticeable thing is the cultivation of ramtil (*Guizotia abyssinica*) in fairly wide area. This is cultivated from VI to I in this village. The fact that this plant is widely cultivated at further south in Nepal and India suggests that Syabrubensi has more or less subtropical climate instead of its location deep in the Himalaya.

## II-9 Right Bank of the Langtang Khola

A very steep climbing up along the right bank of the Langtang Khola from Syabrubensi (ca 1400 m) to Yala (ca 4600 m) is the final stretch to arrive the highest place of the agricultural activity in the profile. The road goes along the foot of the south-facing slope of the Mount Langtang Lirung (23,771 ft). Three representative places are selected to show their landuses.

*Syarpagaon (Loc. 16)*

Syarpagaon is a village of the so-called Langtang Sherpas. People were seen wearing Tibetan style cloths and answered to the authors in the Tibetan calendar instead of the Nepalese one. This is a world of the Tibetan type culture. The Tibetan calendar is translated into the Nepalese one and shown in the cropping chart.

The sample site is about 2550 m. Near the site, pure stands of *Quercus semicarpifolia* are found in places. *Tsuga* is also commonly seen. In some of relatively open places, *Prunus napaulensis* (?) is quite dominantly found. The typical cropping pattern found here is as follows.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII
upland			Maize							Wheat									

The core cropping pattern is the rotation of maize and wheat. Wheat may be replaced by barley, which has the same growth period as wheat. A variety of naked barley locally called *Karu* is also grown from VIII to XI. Among minor crops is potato (II-VII). People usually do not adopt double cropping, except for the case of radish, which is grown after maize from VIII to XI. African millet, grain Amaranths, mustard, buckwheat and upland rice are completely lacking.

Snow falls but does not harm crops. The most serious damage is usually caused by winds on wheat, which rage before and during the flowering of the plant. Animal grazing is important and an average family has 13 to 14 animals including sheep, goats, cows and yaks.

*Langtang (Loc. 17)*

Langtang is another village of the Langtang Sherpas. This is a village located on a

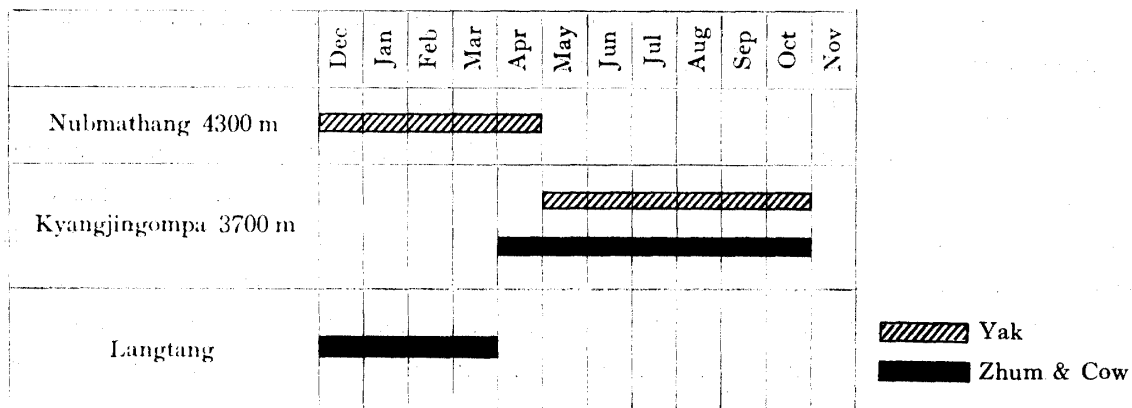
terminal moraine. Even below this village, there are several broken moraines, but this is the first one of large scale and well preserved. On the moraine, what Sherpas call *Mosur* and *Kisur*, or *Rhododendron setosum* and *R. nivale*, are ubiquitous. *Abies* and *Picea* are seen on near-by mountain slopes.

The cropping pattern observed at about 3500 m is as follows.

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV
on moraine								Potato								
								Bitter Buckwheat								
								Barley								
								Wheat								
								Turnip								

The crop assemblage shown above is very much different from others. Potato is the most important crop and then comes bitter buckwheat (*Fagopyrum tataricum*). A short note is needed on bitter buckwheat here. Local names of buckwheat are complicated. According to Ujihara,<sup>9)</sup> there are two species of cultivated buckwheat; *Fagopyrum esculentus* and *F. tataricum*, whose distribution ranges are about 100 m through 2000 m and about 1300 m through 4000 m respectively. *F. tataricum* is further subdivided into two varieties; the sweet one with white skin and the bitter one with dark brown skin. Now there are local names for buckwheat; *mitho* (sweet) and *tito* (bitter). But the usage is confusing; when they are used in the Hill region *mitho* stands for *F. esculentum* and *tito* *F. tataricum*, while in the Alpine region, for instance in Sherpa villages, *mitho* means the sweet variety of *F. tataricum* and *tito* the bitter variety of *F. tataricum*. The authors collected informations through a Sherpa interpreter, who repeatedly emphasized that he was using the words in the sense of the Sherpas. Bitter buckwheat in this paper should be understood as the bitter variety of *F. tataricum*. Now, bitter buckwheat is found only at higher levels than about 3000 m above sea level in this valley. No crop can be grown through winter. Maize is completely lacking. Apparently the high altitude induces this particular cropping pattern.

Real characteristic of this village is, however, found in the animal raising. At Langtang village, even the poorest has five to six large animals and the riches have more than forty. They do not raise goats. They raise a small number of sheep but the most important ones are such large animals as yak, zhumi that is a cross-breed of yak and ox. With these animals they make transhumance migrating between their permanent village and summer grazing grounds at higher elevations. The movement of the animals are schematically shown in the following chart.



The permanent village is located at the low place (ca 3400 m), many summer grazing grounds are located at higher levels like Nubmathang (ca 4300m), and between them is located a government run cheese factory at Kyangjingompa (ca 3700 m). Yaks, both male and female, are left in wild at Nubmathang from December through April. During this time animals run dry. May through October is the period of milking. Yaks are fetched down to Kyangjingompa for the convenience of supplying milk to the cheese factory. In November, the animals are further brought down to the permanent village for stubble grazing on buckwheat and wheat fields. And in December, they are sent to the higher altitude. Yaks are very tough animals. They can survive winter at this high altitude.

Zhums and cows are kept at Langtang all through the cold season from November to March. Only after April, they are sent to Kyangjingompa to supply milk to the factory. During this time some herds may be sent as high as Nubmathang looking for grass. When animals stay at high altitude, people also stay with them living in stone huts. The life pattern at the Alpine region is thus very heavily dependent on animal raising. An informant told us that in spite of their large holding of animals they faced shortage of ploughing animals during early summer, because all the animals were away from the village sent to the summer grazing grounds.

### III Vertical Landuse Zones

Several things become clear on analysis of the data recorded in the previous chapter. They are briefly summarized under the headings of 1) crop pattern, 2) rice farming system, 3) upland crop farming, and 4) animal grazing.

#### III-1 Crop Pattern

All the sample localities described in the previous chapter are plotted on the N-S profile of Fig. 1. The figure clearly shows five zones of different crops. They are the paddy dominant zone, two maize-millet and paddy zones, the maize and wheat zone, and the potato and bitter buckwheat zone.

##### (a) Paddy dominant zone

Localities 1 and 2 represent this zone. Rice predominates absolutely. This zone coincides with the Gangetic plain and Terai.

(b) Maize-millet and paddy zone with tropical plants

Localities 3, 4, 5, 7 and 12 belong to this zone. This is the zone in which the maize-millet combination dominates on the hill slopes and paddy dominates in the valley bottoms. The millet is African millet (*Eleusine coracana*) and this is characteristically inter-planted between standing maize plants. Double cropping of rice is possible where water is available. Wheat may be planted after rice but this is a recent fashion, and the techniques are alien. Tropical plants such as mango, papaya and sugar cane are also commonly seen. This zone comprises the lowest portion of the Hill region.

(c) Maize-millet and paddy zone without tropical plants

The cropping pattern of this zone is quite similar to that of the maize-millet and paddy zone with tropical plants. The only difference is that this zone lacks tropical plants and double cropping of rice is usually impossible. This zone comprises the main portion of the Hill region.

(d) Maize and wheat zone

There is still some millet but this plays only a minor role. Wheat is very important, and this plant is traditional here, while it is not so in the maize-millet and paddy zone. The most typical cropping pattern is the rotation of maize and wheat with millet. This zone comprises the high and northern parts of the Hill region. Localities 13, 14 and 16 fall in this zone.

(e) Potato and bitter buckwheat zone

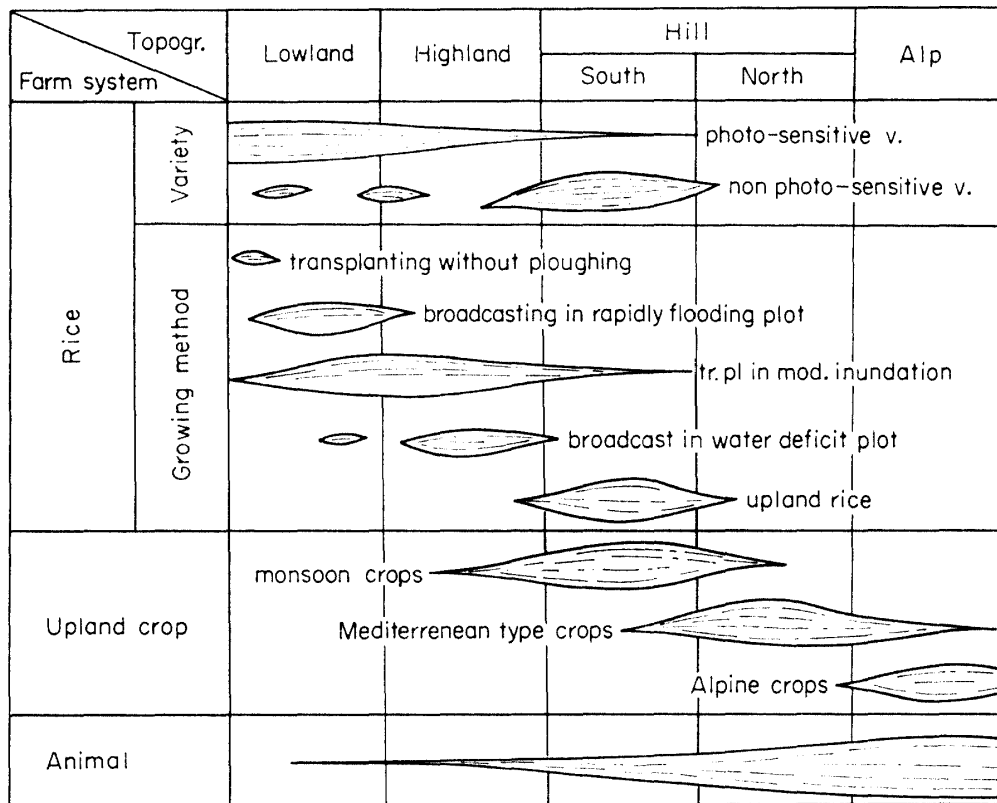
Locality 17 represents this zone. The most important crops are potato and bitter buckwheat. Wheat and barley are also grown here, but they are never grown as winter crops. Animal grazing is very important. This zone coincides with the Alpine region.

### III-2 Rice Farming Systems

The farming system differs with the ecology. Fig. 2 shows farming systems according to topographic regions. From the chart, the following facts can be read.

(a) Rice varieties

*Aman* rice is a typical photo-sensitive variety of rice. A photo-sensitive variety is a variety that grows during summer time and ripens in autumn when the days become shorter. *Aman* rice dominates in the Lowland and Highland regions. Upland rice, which is locally called *gaiya*, is a kind of non photo-sensitive rice. A non photo-sensitive variety is a variety which ripens in a fixed growing period regardless of the season. Minor varieties in the Lowland and Highland such as *Aus* and *Boro* rice also belong to the non photo-sensitive group. Roughly speaking, the poorly drained lowlands are the heart land for photo-sensitive varieties, while the well drained hill slopes are the core area of the non photo-sensitive varieties. These two varieties merge into each other in such a way that the photo-sensitive ones creep up along the valley bottoms of the Hill region, while the non photo-sensitive ones come down and

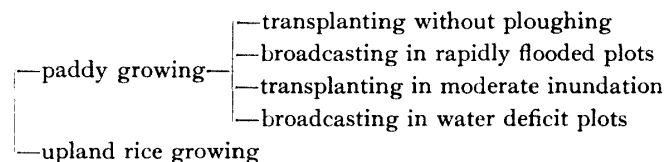


**Fig. 2** Vertical landuse zones of monsoon Asia, showing the elements of the farming systems.

expand their territory selectively on relatively elevated plots in the Lowland region.

(b) Rice growing methods

Rice growing methods are classified as follows.



Transplanting without ploughing is found around ponds and marshes where the water level during the rainy season is too high for rice to be grown. Transplanting is carried out as the water level is decreasing toward the beginning of the dry season. That no ploughing takes place is attributable to the marshy conditions. Weeding is done by hand in the water and the rice plants are then transplanted. This transplanting without ploughing is found in coastal zones too, where inundation is perennial. People just cut down grasses with huge knives and transplant long seedlings. The rice is rainy season rice. Transplanting without ploughing is the particular method adopted in the lowest levels of the Lowland region.

In those places where the ground is dry in the early rainy season but flooded very rapidly under very deep water once a flood arrives, transplanting cannot be carried out. The only way farmers can cope with this environment is to broadcast rice seeds in the early rainy season

on uninundated plots so that the rice can grow tall enough to survive the deep inundation when the flood arrives suddenly. Rice grows together with weeds in the uninundated condition, but when the flood submerges the field, the weeds are all drowned and only the rice plants, which are especially flood-resistant varieties, can grow, keeping up with the flood level. When the flood recedes the plants bear grain. A typical example is the so-called floating rice. As it is in its natural state, the major part of the Lowland region is cultivated by this method.

Transplanting in moderate inundation is practised where the hydrographic condition is moderate by nature or controlled by some means. Fields are prepared by ploughing and harrowing in the early rainy season and then transplanted with seedlings. This is the most common method adopted in many parts of the Highland, the valley bottoms of the Hill region and some parts of the Lowland. Transplanted *Aman* rice is an example.

In those places where a water supply for transplanting is not secured during the transplanting season, the last method that is broadcasting in water deficit plots appears. Fields are leveled and ploughed under dry conditions and seeds are broadcasted. Seeds germinate and grow under uninundated conditions, but they are inundated in the midst of the rainy season and grow as paddy rice. Weeding is a serious problem in this case because the inundation does not become deep enough to kill weeds. *Aus* rice is often cultivated by this method, and some *Aman* rice, particularly in Terai, is also grown in this way. In general, this method is found in relatively elevated portions of the Lowland and Highland.

In the case of upland rice, rice plants are never brought under inundated conditions. Fields are in most cases ploughed but not leveled, and rice seeds are sown in rows or broadcast. But sometimes small holes are made with a stick and several grains of rice are planted in each hole. This method is found on the hill slopes of the Hill region.

Generally speaking, transplanting is practised in those plots where the water depth in the field can be kept within a certain range during the transplanting season. By contrast, broadcasting always occurs where a depth of water suitable for transplanting cannot be obtained during the season due either to untamable floods or the lack of water.

### III-3 Upland Crop Farming

The profile in Fig. 1 shows three crop zones in the Hill and Alpine regions. They are a) maize-millet zone, b) maize and wheat zone, and c) potato and bitter buckwheat zone. These can be interpreted as follows.

#### (a) Maize-millet zone

Maize and millet are accompanied by upland rice and buckwheat. These are all crops originating and flourishing in monsoon areas. So this zone is a zone of monsoon type crops.

#### (b) Maize and wheat zone

Besides maize and wheat, the zone has barley, potatoes, buckwheat and radish. Upland rice and millet are minor here. Although monsoon type crops like maize are quite common, other crops such as wheat and barley which are Mediterranean type crops<sup>9)</sup> are also commonly

found. This zone may be described as the zone of co-existence of monsoon and Mediterranean type crops.

(c) Potato and bitter buckwheat zone

The monsoon type crops disappear completely. Mediterranean type crops still flourish, but we have a new element here; that is bitter buckwheat (the bitter variety of *Fagopyrum tataricum*). The authors still do not know whether the bitter variety of *F. tataricum* is the real element which is peculiar to the very high altitude or not. But at least it is true that this variety dominates in higher levels than 3000 m. The dominancy of the bitter buckwheat may be taken as an Alpine feature of the crop pattern. The zone can be considered to be composed of Mediterranean and Alpine type crops.

To summarize; the Hill and Alpine regions are stratified into three zones from the southern lowlands to the northern highlands as (a) the zone of monsoon type crops, (b) the zone of monsoon type crops with Mediterranean type crops, and (c) the zone of Mediterranean type crops with Alpine type crops. The monsoon nature of the crops weakens increasingly with higher altitude.

#### III-4 Animal Raising

Animal raising can be seen in all the topographic regions, but its importance differs from one region to another. The following chart shows the degree of importance of animals for each region.

	Alpine	Hill		Highland	Lowland
		north	south		
transhumance	○				
cheese	○	○			
milk	○	○	○	○	
manure	○	○	○	○	
plough	○	○	○	○	○

Detailed discussion of animal raising is neglected in this paper. But a clear fact shown by the above chart is that the importance of animals is the highest in the Alpine region and decreases with lower altitude. Animal raising is the essential feature of life in Tibet where the environment is too harsh to cultivate the soil. It is not unreasonable to suppose that animal raising in the Alpine region is a sort of overflow from Tibetan traditions. The further away we go from Tibet, the smaller the importance of animal raising. The monsoon climate, which is primarily a climate suited for an arable type of landuse, particularly summer crops, degenerates with higher altitude into a cool Alpine climate where animal grazing is more appropriate than arable farming.



### Acknowledgements

This is a part of the results of the research project "A Survey on Nature, Ecology and Cultures in the Area of Cino-Indian Civilizations" headed by Prof. S. Iijima, University of Tokyo of Foreign Languages. The project is granted by the Ministry of Education of Japan. During the field survey, from July through November of 1975, the senior author made research under the auspices of the Department of Geography, Institute for Nepalese Studies, and CEDA of Tribhuvan University, Katmundu. The staffs of the above-mentioned institutions kindly gave the author many of valuable informations and instructive suggestions. Mr. Norbu Zambu's effort as an interpreter as well as an assistant for whole the research period must also be highly appreciated. The junior author was stationed at the Department of Irrigation and Meteorology, Ministry of Agriculture, Nepal as a UNDP expert and joined the survey from time to time. He is grateful for the cooperation and assistance extended by the local counterparts and the colleagues. The authors are grateful to professor T. Watabe of Kyoto University for helpful comments.

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